REMARKS

New independent claim 28 was added. No new matter was added. Accordingly, claims 3, 4, 7, 8, 16-19, 23, 24, 27 and 28 are pending. Applicants submit arguments for overcoming the rejection based on the prior art of record. Accordingly, Applicants respectfully submit that the present application is in condition for allowance.

I. Claim Rejections – §103(a)

In the FINAL Office Action, claims 3, 4, 7, 8, 16-19, 23, 24 and 27 are rejected under §103(a) as being obvious over JP 06-177128 A in view of U.S. Patent No. 6,451,135 B1 issued to Takahashi et al..

In the FINAL Office Action, it is readily admitted that the disclosure provided by the JP '128 reference merely teaches the claimed copper alloy composition with respect to thin film copper wiring produced by a sputtering operation. All other limitations required by the claims of the present application are met by modifying the sputtering target used in JP '128 (although never discussed in detail in JP '128) according to the teachings provided in the disclosure of the Takahashi et al. reference. For example, in the FINAL Office Action, it is concluded that:

> "... it would have been obvious to one having ordinary skill in the art of the cited references at the time the invention was made to control grain size and x-ray diffraction ratio as taught by Takahashi because the set forth benefits and function entail the motivation of one skilled in the art to make a claimed sputtering target, in the expectation that compounds similar in structure will have similar properties."

Applicants respectfully request reconsideration and removal of the above referenced rejection for each of the following reasons:

(i) The disclosure provided by the Takahashi et al. reference expressly teaches away from the composition of the thin film and sputtering target disclosed by JP '128 and that required

by the claims of the present application, thus one of ordinary skill in the art would not combine the references in the manner required to make the rejection;

(ii) The stated reasoning for combining the references ("because the set forth benefits and function entail the motivation of one skilled in the art to make a claimed sputtering target, in the expectation that compounds similar in structure will have similar properties") is a mere conclusory statement that is insufficient to support the legal conclusion of obviousness;

(iii) The cited references fail to disclose, teach, suggest and/or provide a motivation for the limitation in independent claims 3, 7 and 28 of the present application with respect to the absence of precipitates in the structure or body of the sputtering target; and

(iv) The purpose and role of the Al in JP '128 differs with respect to object, usage, configuration and effect and thus fails to render obvious to one of ordinary skill in art the sputtering target of the present invention which is specifically adapted for forming a seed layer of a semiconductor device, not copper wiring.

(i) Takahashi et al. Teaches Away from the Claimed Invention

"Teaching away" is the antithesis of the art suggesting that the person of ordinary skill in the art go in the claimed direction. Essentially, "teaching away" is a per se demonstration of lack of obviousness. In re Fine, 873 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988).

The above referenced rejection requires the teachings of Takahashi et al. to be applied to that of JP 06-177128. However, the disclosure of Takahashi et al. **expressly** directs one of ordinary skill in the art away from such a combination.

On column 1, lines 5-39, the disclosure of Takahashi et al. discusses "copper wiring materials". On column 1, lines 40-45, Takahashi et al. specifically cites and discusses the JP 06-177128 reference. For example, the Takahashi et al. reference states:

> "***Patent Application Kokai No. 6-177128*** discloses a thin film wiring material of a copper alloy containing 0.02-20 atom % Al or Si. The alloy is oxidized to form an oxide film in which Al or Si is diffused and concentrated on the wiring surface so as to enhance the oxidation resistance of the surface."

Thereafter, on column 1, lines 46-52, the Takahashi et al. reference teaches that there are disadvantages with the copper alloy thin film of JP 06-177128. For example, the Takahashi et al. reference states that:

> "A ***major problem*** common to the abovementioned methods is an increase in electric resistance by the addition of another element. An increased electrical resistance retards signal transmission and adds to power consumption. For this reason, it has been necessary to put an upper limit to the proportion of the additional element so that the electrical resistance is as low as that of pure Al, i.e., 2.7μΩ·cm or less."

Thereafter, the Takahashi et al. reference teaches a specific limit with respect to Al content. For example, on column 2, lines 20-32, and on column 3, lines 22-35, the Takahashi et al. reference discloses that Al is considered an "impurity" that "***must*** also be minimized." The Takahashi et al. reference teaches that "light metal elements" such as Al "***must*** be reduced in proportions, to ***1 ppm or less***, preferably 0.1 ppm or less".

Accordingly, the Takahashi et al. reference specifically identifies JP '128 and its inclusion of Al, identifies specific problems relative to JP '128 and its Al content, and **expressly teaches away** from the Al content taught by JP '128 whereby it requires Al content to be 1 ppm or less. The Takahashi et al. reference requires the use of virtually no Al in a copper sputtering target for forming thin film copper wiring. Thus, one of ordinary skill in the art is led by the

teachings of Takahashi et al. in an opposite and contrary direction required by that of the present invention.

One of ordinary skill in the art is taught by Takahashi et al. that Al content should be reduced to substantially zero. Thus, it would not be obvious to one of ordinary skill in the art to modify the thin film with Al content of JP '128 based on teachings of the sputtering target of the Takahashi et al. reference which requires no Al content.

For at least this reason, Applicants respectfully request reconsideration and removal of the obvious rejection of the claims of the present application (which requires a specified amount of Al content) based on the contrary teachings of JP '128 in view of the Takahashi et al. reference.

(ii) No Adequate Rationale for Combination of References

The U.S. Board of Patent Appeals has consistently held that rejections on obviousness grounds cannot be sustained by mere conclusory statements. Instead, there must be articulate reasoning with rational underpinning to support the legal conclusion of obviousness.

Applicants respectfully submit that a proper *prima facie* case of obviousness cannot be made under 35 USC §103(a) with JP '178 in view of the Takahashi et al. patent because an adequate rationale has not been articulated for such a combination and modification. Applicants respectfully submit that the reasoning "because the set forth benefits and function entail the motivation of one skilled in the art to make a claimed sputtering target, in the expectation that compounds similar in structure will have similar properties" is a mere conclusory statement and is insufficient to support the legal conclusion of obviousness. One of ordinary skill in the art using common sense at the time of the invention would not have reasonably combined the

teachings of JP '128 (which requires Al content) with that of the Takahashi et al. patent (which requires no Al content and teaches away from Al content).

For at least this reason, Applicants respectfully request reconsideration and removal of the obvious rejection of the claims of the present application based on the contrary teachings of JP '128 in view of the Takahashi et al. reference.

(iii) Absence of Precipitates

Independent claims 3 and 7 of the present application require a target "having a structure that does not substantially contain any precipitates", and new independent claim 28 requires a sputtering target body "containing no precipitates". No new matter was added; for example, see page 5, lines 4-5, and page 11, Table 1, of the present application, as filed.

As explained by the specification of the present application (page 5, lines 5-6), when the additive amount of Al exceeds 0.2wt%, "precipitates will arise during the manufacture process of the target." The problem with precipitates is discussed on page 5, lines 7-21, of the present application as follows:

> "When precipitates exist in the target structure, particles will be generated since the sputtering rate between the matrix phase and precipitates phase will differ, and problems such as wiring disconnection in the semiconductor device will occur.
>
> In particular, it has become evident that these precipitates are formed in the center (middle) of the target separate from the surface, and not near the target surface.
>
> Therefore, problems caused by precipitates occur not during the initial phase of sputtering, but from a state in which the erosion of the target caused by sputtering has progressed to a certain degree. In other words, precipitates are caused by minute particles getting mixed into the sputtered film, or due to the micro unevenness of the film composition midway during sputtering.
>
> As a matter of course, since such uneven portions of the seed film generate uneven electric fields, the copper plating film structure will become uneven and minute, and electromigration resistance characteristics will deteriorate, which is

obviously unfavorable. Although the problem is often overlooked since it does not occur in the initial states, this is a major problem."

Both cited prior art references fail to disclose any steps taken to eliminate the otherwise normal formation of precipitates within the body of the sputtering target.

For example, Takahashi et al. disclose a sputtering target and thin film wiring having no more than 1 ppm of Al. Thus, since precipitates would not form in the target of Takahashi et al. due to the absence of Al content, there is no common sense reason provided to one of ordinary skill in the art by Takahashi et al. with respect to preventing the formation of precipitates.

Turning to JP '128, its disclosure is almost exclusively directed to a thin film, not a sputtering target or its method of manufacture. For example, the only reference at all in JP '128 with respect to a sputtering target is in Paragraph No. 0010 of JP '128. This paragraph merely discloses the composition of a copper alloy target and fails to disclose any other characteristic or method with respect to the target.

Accordingly, if one of ordinary skill in the art were to follow either prior art reference, either a target without the required Al content would be prepared (i.e. according to Takahashi et al.), or a target having the required composition as well as precipitates would be prepared. There is simply no combination of teachings that would make it obvious to one of ordinary skill in the art to provide a copper alloy sputtering target having 0.2 to 5wt % Al and no precipitates.

With respect to the sputtering target of the present invention, page 6, lines 20-25, of the present application reads, as follows:

> "Further, upon manufacturing the target, after performing homogenization heat treatment with a certain degree of thickness, in the subsequent cooling step, it is important to sandwich this with metals having a large thermal capacity such as copper plates underwater, and to increase the cooling effect without generating a vapor layer on the surface thereof. This is because if a vapor layer is formed, the cooling effect will significantly deteriorate."

This process step also forms the final process step required by withdrawn claim 27 of the present application.

This cooling step is discussed with respect to the Examples and Comparative Examples described in the present application. Examples 2-1 and 2-2 and Comparative Examples 2-1 and 2-2 are directed to Cu-Al alloy sputtering targets (see page 7, line 27, to page 8, line 21). As disclosed on page 8, lines 2-5, Example 2-1 was prepared as follows:

> "Thereafter, this was rolled until it became φ 360x10t with cold rolling, heat treatment was performed thereto at 500°C for 1 hour, and this was sandwiched with copper plates under water for forced cooling. Moreover, this was machined processed to obtain a discoid target having a diameter of 13 inches and a thickness of 7mm."

With respect to Example 2-2, the same process steps were utilized as for Example 2-1. With respect to Comparative Examples 2-1 and 2-2, all process steps are identical to that used for Example 2-1, except that underwater cooling was replaced by "cooling in a furnace." For example, see page 8, lines 14-22, which reads as follows:

> "Comparative Example 2-1
>
> Using the same materials as Example 2-1, after performing heat treatment at 500 degrees for 1 hour, this was cooled in a furnace. The other conditions were the same as Example 2-1. As a result, a copper alloy target containing 1.0wt% of Al was prepared.
>
> Comparative Example 2-2
>
> Using the same materials as Example 2-2, after performing heat treatment at 500 degrees for 1 hour, this was cooled in a furnace. The other conditions were the same as Example 2-2. As a result, a copper alloy target containing 0.5wt% of Al was prepared."

Accordingly, Example 2-1 and Comparative Example 2-1 of the present application are identical with the only exception being the process step of underwater cooling between plates versus the process step of cooling in a furnace. The same is true between Example 2-2 and Comparative Example 2-2.

On page 11, in Table 1, the present application reveals that "Precipitates" for Examples 2-1 and 2-2 are "Not Observed". However, Table 1 shows that amounts of "Precipitates" were observed for the Comparative Examples. Keep in mind, the only difference between the Examples and the Comparative Examples was the process step of underwater cooling between plates and cooling in a furnace.

Thus, Applicants respectfully submit that the cited prior taken alone or in combination fail to disclose a sputtering target having the required composition and no precipitates.

For at least this reason, Applicants respectfully request reconsideration and removal of the obvious rejection of the claims of the present application based on JP '128 in view of the Takahashi et al. reference.

(iv) Different Purpose and Role of Al Content

As discussed above, Takahashi et al. direct one of ordinary skill in the art to have virtually no Al content (1 ppm or less) in its copper sputtering target.

In direct contrast, JP '128 requires 0.02 to 20 atomic percent of Al or Si in copper alloy thin film wiring. The purpose of the Al in the thin film wiring of JP '128 is accurately stated on column 1, lines 39-45, of the Background section of the Takahashi et al. patent.

JP '128 describes forming copper wiring by way of sputtering. In JP'128, a specified amount of Al or Si content is included in the wiring for purposes of forming a surface oxide layer. For example, an oxidation treatment is provided to the film to cause the Al or Si to diffuse to the surface of the film thereby forming an outer barrier layer resistant to oxidation. The Al or Si is dispersed and concentrated along the surface of the wiring, and thus, the Al and Si are removed from the internal bulk portion of the wiring which essentially consists of pure copper.

As a result of the non-uniform presence of Al or Si in the copper wiring, the bulk internal portion of the wiring will have high conductivity (equal to that of pure copper) and the outer layer of the wiring will resist oxidation due to the high concentration of Al or Si.

The thin film having the above referenced surface barrier layer disclosed by JP '128 could not be used as a seed layer for a semiconductor device. Typically, a barrier film of TaN or the liked is formed on an insulating film in order to prevent diffusion of copper to the interlayer insulating film. Subsequently, a thin film copper seed layer is formed on this barrier film via a sputtering process. Thereafter, a thick film copper wiring is formed by an electrolytic copper plating process. Such a plating process requires energization, thus the seed layer is required for use in turning on the electric current to enable growth of the electrolytic copper plated film. Accordingly, a seed layer is an essential layer for forming copper wiring via the electrolytic copper plating method, and the seed layer does not itself assume the role as wiring of the semiconductor device.

Unlike the copper wiring thin film of JP '128, the copper alloy seed layer of the present invention requires use of a sputtering target having a specific crystal orientation by adding aluminum, forming a uniform copper alloy seed layer by sputtering the target, and uniformly growing the electrolytic copper plated film without bias based on the foregoing uniform seed layer. The uniformity and crystal orientation of the seed layer is critical for its success and the formation of a uniformly grown electrolytic copper plated film.

If the oxide film formed by adding the aluminum in JP '128 is used as the surface of a seed layer, electrolytic copper plating would fail. The role of the aluminum required in the target for forming a copper alloy seed layer according to the present invention is clearly different from the role of the aluminum described in JP '128. Accordingly, the technical concept of the present

invention and the technical concept of JP '128 are clearly different. Of course, the technical concept of Takahashi et al. is also different since no Al content is taught. Thus, the claimed invention is not taught to one of ordinary skill in the art by the cited prior art references.

In addition, while uniformity and crystal orientation are very important in the sputtering target and seed layer of the present application (so that an electrolytic copper plated film can be uniformly grown on the seed layer), uniformity and crystal orientation are of no concern to JP '128. This is because the sputtering film of JP '128 is required to be subjected to oxidation treatment causing the Al or Si to diffuse to the surface layer of the copper wiring. Thus, the thin film of JP '128 is not uniform and uniformity is not desired. Further, the Al or Si content of JP '128 is required to be concentrated on the layer of the wiring to form a barrier layer, and there is substantially no Al or Si content in the pure center section of the wiring required by JP '128. Accordingly, there is no common sense reason for one of ordinary skill in the art to adjust the crystal orientation or uniformity of JP '128.

Further, Applicants respectfully submit that it would not be obvious to one of ordinary skill in the art to control the crystal grain size and X-ray diffraction ratio of the copper alloy of JP '128 based on the Takahashi et al. patent. The optimal crystal grain size and texture of a target greatly depend upon its composition. Thus, the crystal grain size and texture that may be optimal for the high purity copper target of Takahashi et al. is not necessarily favorable for the copper alloy composition of JP '128. It would be an error to apply the condition of the crystal grain size and texture of the high purity copper of Takahashi et al. to the copper alloy composition of JP '128.

For at least these additional reasons, Applicants respectfully request reconsideration and removal of the obvious rejection of the claims of the present application based on JP '128 in view of the Takahashi et al. reference.

II. Conclusion

In view of the above amendments and remarks, Applicants respectfully submit that the rejection has been overcome and that the present application is in condition for allowance. Thus, a favorable action on the merits is therefore requested.

Please charge any deficiency or credit any overpayment for entering this Amendment to our deposit account no. 08-3040.

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